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Open Innovation applied to Supply Chain Management

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Disclaimer

The following paper was written in its entirety by the author, Tiago Polleri Falcão, and it constitutes an integral part of the Master of Science in Management at the Nova School of Business and Economics. The references indicate which literature sources have been used and all sources are cited in-text and in the bibliography.

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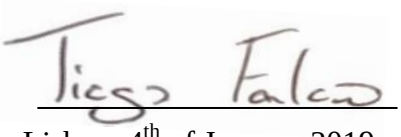

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Executive Summary

The globalized nature of today's world presents new sets of opportunities and challenges for companies to harness and overcome. Open innovation is one of these opportunities, whereby breaking-down company boarders and integrating a large spectrum of stakeholders in the development of new ideas allows companies to have a greater space in which innovative solutions may be found. The main concept behind open innovation is that firms are no longer restrained by their own capabilities, as they collaborate with external resources to advance their technology and pursuit innovative solutions leading to competitive advantages. In this paper, an analysis is conducted regarding the feasibility of applying open innovation to the development of optimized supply chains. By reviewing current relevant literature combined with primary quantitative and qualitative data, this paper attempts to provide some insight to the current usage of open innovation in this field.

From the work performed, it is possible to verify that open innovation has been present in developing efficient supply chain processes in various industries, such as automotive and food processing, through integrated efforts of key players and their main suppliers. Increasing the number of stakeholders in creating new solutions may present a challenge to such companies, as a key driver for success has been stable relationships that may be disrupted by open innovation. Thus far, open innovation in supply chains has had a greater presence in the form of supplier participation in earlier stages of the product life cycle, as customer participation has so far been limited. Open innovation may further impact a supply chain company's corporate strategy, alter traditional R&D practices and require a human resource adjustment in order for open innovation to be properly implemented. Finally, open innovation is likely going to remain a dominant trend which firms should actively seek to engage with. Macro-trends, such as a shorter product life cycle and technological improvements, seem to

support the adoption of open innovation, which may further expand partner participation in the supply chain across the whole product conception process.

Contents

I - List of Acronyms

CI – Closed Innovation

CII – Cross Industry Innovation

GE – General Electric

HRM – Human Resource Management

IT – Information Technology

ICT – Information Communication Technology

IP – Intellectual Protection

KPI – Key Performance Indicator

M&A – Mergers and Acquisitions

MIT – Massachusetts Institute of Technology

OI – Open Innovation

PLC – Product Life Cycle

R&D – Research and Development

SCM – Supply Chain Management

1 – Introduction

The 21st century has presented firms with new sets of challenges to overcome and opportunities to harness to their benefit. Traditional business models and supply chains have been forced to adapt to the ever-changing landscape brought by globalization, together with a new "age of information", enabled by technological advancements and instantaneous communication (Soresina, 2017). Presumably, one of the most radical changes in traditional business models is seen in the way companies innovate. In the beginning of the 21st century U.C. Berkeley Professor Henry Chesbrough coined the term "Open Innovation" (OI), which has since increasingly become a wide-spread trend, deeply reforming the process in which innovation has been conducted at company level. Traditionally, R&D departments were solely responsible for product and services innovations using resources inside the company, in what has since been called "Closed Innovation" (CI) (Chesbrough, 2003). One of the primary focuses of OI relies on facilitating communication and establishing knowledge-flows inside the firm as a whole (internal OI) and with external third-parties outside of the firm (external OI). This way, new ideas, innovations, and alternative paths to markets may be retrieved from areas other than the R&D department, or even from outside the firm (Chesbrough, 2003). As Professor Chesbrough put it: "Open Innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology" (Chesbrough, 2005)

OI has, therefore, set forth a new borderless limit to the innovation process which the firm is able to harness to its advantage. The paradigm-shift presented by OI may encompass virtually all business segments and firm-level departments, including modern supply chains, where knowledge flows are limited (either at an internal or external level) (Kellner, 2014). In essence, OI views these knowledge flows as the main vehicle to overcome the "silo vision"

(also commonly referred to as "tunnel vision") which has limited the scope and opportunity-horizon a firm may choose from (Barak, 2017).

1.1 – Research question and methodology

This paper's aim is to assess the overall potential of OI in what regards the management of supply chains. The ultimate goal is to be able to answer the following questions:

1. What is Open Innovation and how can it best be applied to Supply Chains?
2. What are the risks and benefits involved with the application of Open Innovation in Supply Chains?

In answering the questions above this paper combines a mix of both primary and secondary data. Primary data was achieved by conducting questionnaires to experts in three areas: (1) Human Resource Management (HRM); (2) Corporate Strategy; (3) Innovation and R&D. Another separate questionnaire was conducted to professional executives regarding the usage of OI in their firms as well as their overall perception of the potential of OI. Having expert's opinions and insights should allow for a better assessment of potential advantages and disadvantages expected with the implementation of OI initiatives. Secondary data was obtained from available relevant literature, where both the data and literature are discussed and analyzed.

2 – Literature Review

2.1 – Principals of OI vs. CI

As already mentioned, in its simplest terms, OI can be defined as a paradigm-shift which sets about a new corporate mindset regarding the firms' R&D and innovation processes (Chesbrough, 2005). The essence of OI is to facilitate knowledge outflows (Outbound OI) and

inflows (Inbound OI) in order to maximize knowledge exchanges regarding innovation and potential market paths (see appendix 1 for the differences between Outbound and Inbound OI). The premise on which OI is based upon is one that views organizational boundaries as flexible, as opposed to rigid, and therefore companies are better suited to benefit from external knowledge sources (Barak, 2017) (see appendix 2 & 3 for visual illustrations of OI and CI). OI therefore presents an alternative to the traditional R&D model, which is largely focused on an internal and closed innovative process, often conducted in secrecy from any external sources (in order to avoid any unwanted "spillovers" to competing firms) (Chiaroni, 2010) (see appendix 4 for a table with the principals of OI vs. CI).

2.2 – What trends triggered OI

As mentioned previously, OI presents a paradigm shift to the traditional innovation process. This shift is caused by the possibilities put forward by changing dynamics in available technology; labor and in market definitions (Chesbrough, 2005) (EPSC, 2018). There are growing trends across industries and markets which help push firms on the transition from a mainstream CI mindset to an OI mindset (Brunswicker, 2015). According with (Meige, 2017) and (EPSC, 2018) the most noticeable of these trends are:

1. Growing mobility and number of skilled professionals.
2. Decrease in staff long-term attachment to a single company, resulting in increased employee turnover rates.
3. Increase of venture capital funding. This incentivizes the creation/development of new innovation intensive firms such as start-ups which play a vital role in OI. This is as producers of innovations or new entrants to the industry often act as vehicles to promote industry transformation and restructuring.
4. Increase in product development cycles, mainly due to technological advancements rendering products obsolete at a faster rate.
5. Globalization: both in terms of (1) instant communication made available by ICT's and in terms of (2) less clear distinction of different markets due to market overlaps and integration (certain market boundaries, such as geographical boundaries, are increasingly less perceptible).

2.3 – Advantages and disadvantages of OI

There are various advantages and disadvantages of OI (André Ullrich, 2016). These vary greatly according with the OI model implemented, as well as which knowledge exploiting mechanisms and which OI techniques are used (see appendix 5 to 7 for the centralized and decentralized OI models; OI knowledge exploiting mechanisms and OI techniques). OI may allow for new or improved market paths, but at the risk of disturbing established market paths in the process (Lichtenthaler, 2011). This will likely depend on the specific needs of the firm and its different perspectives for OI (see appendix 8 for the nine firm perspectives regarding OI). A table containing the main advantages and disadvantages of OI may be found in appendix 9.

2.4 – Case studies of OI

General Electric (GE):

GE's incorporation of OI was made easier by the internal knowledge dissemination processes which had been but in place since the 1990's by the then CEO Jack Welch (these processes largely focused on sharing of best practices across departments worldwide – internal OI – and encouraging a bounder less corporate behavior whereby rigidities across departments were diminished) (Lindergaard, 2014). More recently, at an internal level, GE has undertaken a more open and inclusive approach to innovation throughout the whole company, whilst at an external level GE has focused on reinforcing strategic partnerships as well as creating communities of external collaborators where crowdsourcing allows for a faster and more agile innovation process (Lindergaard, 2014).

GE's *GeniusLink* is their main inbound OI initiative. GeniusLink is an online platform where multiple innovation-related challenges are regularly posted and any user (including

GE's worldwide employees) may present a solution to these challenges (GeniusLink, 2018). Monetary compensation is then awarded to the user who submitted the winning solution. Given the wide business scope of GE, GeniusLink is used as the platform for the various other smaller initiatives and programs (GeniusLink, 2018). Other similar initiatives conducted by GE include *FirstBuild.* Firstbuild uses crowdsourcing in its website as a source for product innovation in the home appliance industry. Crowdsourcing is linked to 454 prototypes and 15 products currently on shelf developed by FirstBuild (FirstBuild, 2018).

Samsung:

Samsung has largely focused on four different channels in which to adopt OI (using a mixture of inbound and outbound OI) (Samsung, 2018). According to Samsung's OI website these are (Samsung, 2018):

(1) *Global Consortiums* – Samsung takes part in 13 different international consortiums (such as SEMATECH; WebSummit and IMEC) regarding industries where Samsung operates in. During these consortiums, Samsung and others participants discuss and assess varying issues and divergent viewpoints. These often regard the identification of potential technologies or discussions on standards and guidelines. By taking part in these consortiums Samsung has taken advantage of a beneficial business ecosystem, allowing Samsung to better embrace new technologies and infrastructures, whilst at the same gaining access to external knowledge sources.

(2) *Cooperation with Academia* – Samsung has fostered relationships with various top universities as a mechanism to achieve new technologies; infrastructures and human talent. Samsung's partnership with universities has proven to be beneficial, allowing Samsung to enjoy quality R&D research. Furthermore, Samsung sponsors the training of current

employees and students in universities, resulting in performance improvements of employees and potential talent acquisition of promising students as future employees.

(3) Synergy's with Equipment and Material vendors - Cooperation with Samsung's closest business collaborators allows for a more efficient overall process. This leads to an increase in Samsung's product competitiveness as cooperation's with vendors allows better control of product quality and the manufacturing process of vendors.

(4) Overseas Research Centers – Samsung uses a global network of research centers as vehicles to internalize knowledge regarding emerging technologies or materials. This way, Samsung is able to improve its software and hardware; increase their overall R&D capabilities and better put research projects into practical use.

LEGO:

The OI strategy undertaken by Lego has been implemented on both the production and process side of their business operation (Lindergaard, 2014). Currently, Lego has focused on inbound OI as a source for innovative Lego construction set designs with the potential to be commercialized. In 2008 Lego created their own OI based website called "LEGO Ideas", where Lego is able to crowdsource large amounts of innovative construction set designs (The LEGO Group, 2018). In essence, the website allows users to submit their own construction set designs or otherwise vote on their favorite designs. Voting works as a feedback tool for Lego as it assesses user's preferences as well as indicates the potential commercial success of a particular design (The LEGO Group, 2018). Therefore, Lego is able to obtain new construction set design ideas for future products whilst at the same time being able to sense its expected popularity by the number of votes given to any particular design submitted to their website.

However, “LEGO Ideas” is only one example of how Lego has incorporated OI principals into their R&D operations. Lego currently uses co-creation partnerships with external collaborators as a tool to develop new products (including collaborators from different industries, typically called “Cross Industry Innovation” or CII). Perhaps one of the most innovative products to result from such an external partnership (in this case with MIT Media Lab) is Lego Mindstorms, which first became commercially available 1998 (IdeaConnection, 2011). In essences, these Mindstorm construction sets are programmable robots made in Lego blocks, and ever since their first release in 98’, the capability of the robots has expanded. Lego further uses its Lego Mindstroms website to allow users to submit remixed designs of Mindstorm robots as a crowdsource tool for innovative designs (The Lego Group, 2018).

3 – Supply Chain Management (SCM)

3.1 – What is SCM?

In essence, SCM is responsible for the whole process regarding the production of a good, from the acquisition of the raw materials; product production; and distribution to the customer (CSCMP, 2018). Therefore, SCM refers to a combined number of activities necessary for the successful design strategy; control and implementation of a product’s flow, all of which is conducted under the most streamlined and efficient manner possible (both cost and time wise). These activities include the planning; procurement; production; distribution and client interface throughout the whole supply chain process (CSCMP, 2018).

In order for efficiency to be achieved, SCM focuses on what is commonly referred to as the Seven Rights of Fulfillment. These are: (1) The right product; (2) The right customer; (3) The right time; (4) The right place; (5) The right condition; (6) The right quantity and (7)

The right cost (David L. Anderson, 1997). Being able to fulfill these seven rights helps the supply chain achieve optimization throughout the whole process (from having the product available for order, up to the billing process), thus allowing for good customer satisfaction. Customer satisfaction is vital as it saves cost (from either fixing errors; do-overs; or using extra resources/assets), as well as encourages the customer to reuse the seller's services in the future (CSCMP, 2018).

Two of the most important aspects of SCM are good communication and coordination. It is vital to have adequate communication channels throughout the supply chain as it is the flow of accurate data; financial records and other information that allows managers to make optimal decisions (A.Paton & McLaughlin, 2008). Coordination channels allows for efficiency throughout supply chain process (including demand forecasts; sourcing; assembly and distribution), not only internally at the firm level, but with external partners as well. At the managerial mindset, it is important to view the SCM process as a whole (from the suppliers' suppliers up to the customers' costumers) whilst focusing on specific tangible outcomes to improve upon (using Key Performance Indicators, KPIs, such as revenue growth and cost reduction) (Zamboni, 2011).

3.2 – Coordination and Collaboration in Supply Chains: The "Lean" Supply Chain

For the vast majority of the 20th century, supply chains faced a series of common inefficient characteristics including: High level of inventories; built-in buffers in case equipment breaks-down and large repair areas to mend for poor assembly line quality (Anne-Laure Mention, 2016). These characteristics were common due to the fact that supply chains were often ineffective; disorganized and uncoordinated (A.Paton & McLaughlin, 2008). In order to better

optimize supply chain processes, there was a need to improve coordination in production systems across the whole supply chains.

In 1988, Krafcik used the term "*lean*" when discussing innovative forms of production systems in an article for the Sloan Management Review, based on the best practices of the efficient supply chains in the Japanese automotive industry (Krafcik, 1988). Using Toyota as an example, Krafcik differentiated between traditional and lean production systems arguing that in supply chains: (1) the number of suppliers should be reduced and maintain direct contact with the manufacturing company; (2) suppliers should be increasingly responsible for internal innovation specified for product development; (3) trust across the supply chain should be developed, whilst coordination and control over the chain should be closely monitored (Krafcik, 1988).

These three aspects of lean production systems would deeply alter supply chains during the 90's, as they allowed for cost and time reductions whilst improving quality and coordination throughout the whole chain (Anne-Laure Mention, 2016). Specifically, they allowed for inventories to be kept to a minimum; product defect problems to be minimized and quickly solved; repair areas to become smaller as quality should be achieved within the supply chain; and a continuous flow of production (Anne-Laure Mention, 2016).

3.3 – Supply Chain evolution: From *Lean* to *Open* production processes

Over time, the main principals of lean production systems have been conveyed across industries. Since the 90's, and with the improvement of information communication technologies (ICT's), coordination became increasingly accessible to maintain across supply chains. However, new trends and challenges meant supply chains would struggle given shorter product cycles; rapid technological development; increase in global competition and the outsourcing of supply chain tiers to cheaper markets (Anne-Laure Mention, 2016). As such,

the overarching solution was to increasingly incorporate suppliers in earlier produced development stages.

In essence, supplier integration in the early stages of the product life cycle (PLC) was a first step towards OI implementation in supply chains, given how suppliers were increasingly relied upon as both sources and drivers of innovation (Anne-Laure Mention, 2016). Consequently, the architecture of supply chain relationships started to shift from one formed by dependent hierarchies to one composed of flexible and integrated links between the different supply chain actors (see appendix 10 for visual illustration of collaborator resource utilization in supply chains) (McMahon, 2015). This paved the way for better overall feedback throughout the supply chains as well as better leveraging of supplier know-how. The results of such have empirically shown to be a direct cause for efficiency improvements, with use of KPIs as means of measurement (Arabshahi & Zaafarian, 2014).

3.4 – OI impacts in SCM

In supply chains, OI focuses on the knowledge flows between suppliers and customers. Cooperating and/or complementary suppliers, in or across the same supply chain tier, should therefore seek to enhance knowledge flows in order to enrich and heighten the final innovation output (Anne-Laure Mention, 2016). Emphasis should be given to the development and implementation of communication and harmonization mechanisms, which help integrate supply chain production processes, thus achieving a higher quality of products and reduction of costs whilst by streamlining the supply chain (Aziz, Mahadi, & Mahadi, 2017).

Recent supply chain innovation literature has continuously reiterated the importance of relationships with external actors for successful and meaningful innovation to occur (Anne-Laure Mention, 2016) (Aziz, Mahadi, & Mahadi, 2017). This is true even across supply chain industries, whereby external partnerships with players in different industries have allowed for

significant innovation advancements (cross industry innovation, known as CII, is a common basis for innovation in supply chains) (Zamboni, 2011) (Lazzarotti, Manzini, Pellegrini, & Pizzurno, 2013). The most wide-used innovation practices focus on interactions with suppliers in the supply chain as part of the innovation process. Recent empirical evidence has showed renewed support for how collaborative innovation with suppliers has allowed supply chains to accomplish a higher level of performance (Arabshahi & Zaafarian, 2014). Furthermore, collaborative innovation relationships with suppliers has allowed supply chain managers to better assess opportunities in which to improve upon efficiency and adaptability to the dynamic needs of the markets (Westphal, 2016). Nevertheless, focus should also be given in establishing customer integration as this may be a form of differentiation in an increasingly dynamic market, where customer buyer values are less consistent (mainly due to a faster technological cycle and a shorter PLC) (Anne-Laure Mention, 2016) (EPSC, 2018).

Of the main opportunities regarding collaborative innovation in supply chains the following stand-out: (1) Entrusting innovative responsibility to suppliers has allowed manufactures to better focus on core competencies, allowing a pathway for better internal performance; (2) Supplier innovations are positively associated with impacts in various supply chain KPI's (including cost; product development and quality; as well as improved supply chain adaptability); (3) the leveraging of partners knowledge and know-how (Zamboni, 2011).

Figure 1: OI via external relationships in a supply chains

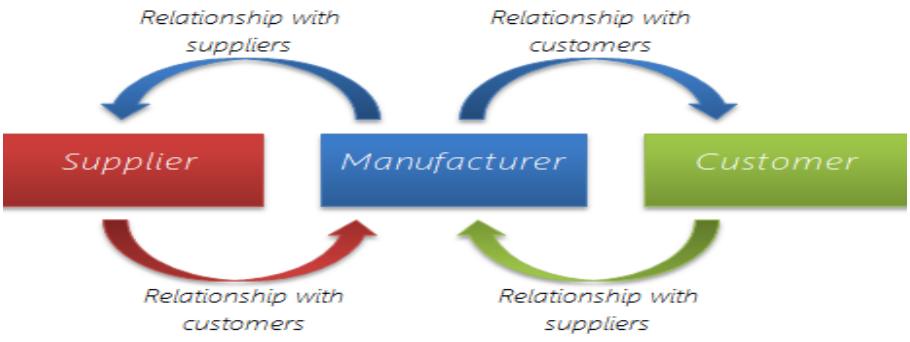

Figure constructed by the author

One of the main limiting factors in supply chain literature seems to be the lack of standardized metrics in which to measure the actual benefits of OI in supply chains (Lau, Lee, & Lee, 2018). Whilst point number (2) in the previous paragraph states that supplier innovations are associated with improved performance metrics, these have so far remain rather vaguely defined which harms the ability to compare best practices across supply chains. (Zamboni, 2011) Moreover, varying KPIs have been applied to measure the benefits of collaborative innovation at multiple points in the supply chain. The lack of clearly defined metrics decreases the ability of existing literature to provide good insight regarding the best practices in supply chain innovation (Zamboni, 2011).

3.5 – OI and SCM: a conflict of goals

OI can appear to have a contradictory nature to that of well-established SCM processes, particularly when given conflicts generated by dissimilarities in OI and SCM goals (Zamboni, 2011). Whilst OI focuses in the upbringing of innovation and new collaborative partnerships, SCM aims to have steady, ongoing relations which must be as clearly established and organized as possible in order to secure cost efficiency (André Ullrich, 2016) (A.Paton & McLaughlin, 2008). It is therefore vital to carefully manage these two focuses when applying OI in supply chains. Some of the greatest risks regarding OI in SCM are often created by fostering new relationships and finding new opportunities, where in doing so the firm risks diluting previous established relationships and procurement patterns, ultimately harming the firm (Westphal, 2016). New opportunities can further conflict with or replace well-established activities in SCM with little guarantees of improved overall efficiency. At the same time, being to risk-averse may drastically reduce the opportunity benefits from OI (Juan Igartua, 2010). The tense relationship between SCM and OI goals is in itself a caution signal which

highlights the difficulties in balancing and managing the need for stability versus the need for innovation in supply chains.

3.6 – Case studies of OI in Supply Chains

OI in the food machinery supply chain of Italian companies:

In 2010 Bigliardi & Bottani conducted a study on the supply chain of food machinery in Italy regarding the use of collaborative processes and open innovation. In their study, they focused on the actors (supplier-manufacturer-customer) relationships across the supply chain. Specifically, Bigliardi & Bottani focused on the actors' perception of innovation; type of innovation developed; drivers of innovation; OI strategy undertaken and benefits of the innovations (see table 1). Bigliardi & Bottani then attempted to identify and assess the mechanisms in which collaboration occurred across the supply chain (see table 2). These are their reported findings:

Table 1: OI in the Italian food machinery supply chain

Findings from Bigliardi & Bottani (2010) – open innovation in the Italian food machinery supply chain			
	Supplier	**Manufacturer**	**Customer**
Perception of innovation	Very relevant, since the company manufactures numerous new products per year	Strategic for achieving competitive advantage and new market fields	Strategic for development of new products
Type of innovation developed	Product innovations, both incremental and radical	Product and process innovations, with a clear orientation of industrial processes	Product and process innovations
Drivers of innovation	Requests by the manufacturer or the final customer; internal R&D activities	Requests by the final customer; analysis of competitors; internal R&D activities	Requests by the customers; health and safety requirements
Open innovation strategy	Cooperation with customers and consequently, with universities	Network of multiple partners, including research labs, universities, consultants and suppliers. Analysis of technical solutions available in different market fields (e.g.: pharmaceutical)	Collaboration suppliers; Universities and research centers
Benefits of innovation of supply chain player	Increased customer satisfaction; better service level delivered to customers; increased the quality of the product manufactured	Increased sales volume; reduced costs; increased competitiveness; increased customer satisfaction	Increased competitiveness; possibility of increasing the yearly number of new products developed

Table constructed by the author based on (Bigliardi & Bottani, 2010)

Table 2: Types of collaboration mechanisms in the Italian food machinery supply chain

Findings from Bigliardi & Bottani (2010) – types collaboration mechanisms in the Italian food machinery supply chain		
	Supplier-Manufacturer relationship	**Manufacturer-Customer relationship**
Type of relationship	Mature (partnership)	Under development
Role of the partnership for OI	Strategic: both partners are critical for the development of new technical solutions	Still limited
Stages of major involvement in innovation	Early stage of new product development (design stage). No direct involvement in the commercialization	Last stages of product development (i.e.: assembling and testing). No direct involvement in innovation
Benefits of the mutual relation	Possibility to focus on its core business; improved performance of the new product or technical solution developed	Possibility to establish long lasting relationships and decrease the cost for acquiring new bottling plants

Table constructed by the author based on (Bigliardi & Bottani, 2010)

OI in supply chains via CII in BMW´s development of iDrive:

In autumn 2001 BMW launched an innovative computer-like screen control device called the iDrive in its BMW 7 series (nowadays commonly referred to as a "Control Display"). This would become one of the most radical changes in user interface in the automotive industry during the years to follow as the automobile industry has continuously incorporated similar computer technology in its products (Enkel & Gassmann, 2010). The iDrive simplified and improved various interactions between the car and the driver, allowing control of a variety of features (such as gear shift; navigation; air conditioning; climate control; lights; telephone; radio and CD music; etc.).

The creation of the iDrive was only made possible due to the integration of new technology from outside the automotive industry (Enkel & Gassmann, 2010). BMW firstly identified a company in Palo Alto called Immersion as a partner for this innovation project. Immersion was the proprietor of a technology called TouchSense which had up to that point only been used by the video game industry (Lazzarotti, Manzini, Pellegrini, & Pizzurno, 2013). Immersion itself had never worked on a project for the automotive industry prior to its partnership with BMW. However, the process of adapting the technology to the automotive

industry was fairly quick, and soon thereafter a prototype was created (Lazzarotti, Manzini, Pellegrini, & Pizzurno, 2013).

There were some setbacks and problems during Immersion's and BMW's partnership as Immersion was unused to dealing with such a large company. The great number of different BMW departments involved in the project made clear responsibility and communication with Immersion difficult. Furthermore, given the truly radical and innovative nature of the project, BMW's engineers remained rather skeptical in integrating the technology in their products (Lazzarotti, Manzini, Pellegrini, & Pizzurno, 2013). Additionally, once BMW's requirements were reached, BMW needed a hardware supplier, and therefore needed a second external partnership, as Immersion could only supply the technology. For this purpose, BMW purchased the rights to the TouchSense application in cars (becoming exclusive for a time period) and selected ALPS (a Japanese electronics group) for the hardware serial production. In compensation; Immersion received a royalty fee for each device incorporated into BMW's cars. The iDrive technology feature has since become included in all of BMW's cars, thus highlighting the relevance of this particular innovation in BMW's supply chain (Lazzarotti, Manzini, Pellegrini, & Pizzurno, 2013).

4 – Analysis of questionnaires conducted to experts end executives

For further assessment of the impacts of OI in supply chains, several academia experts and professional executives were consulted, in the form of either an interview or questionnaire. This way it is possible to obtain greater insight into the future prospects; benefits and short-comings of OI regarding SCM. Academia experts were consulted for three different areas (1 - Corporate Strategy; 2 - HRM and 3 - Innovation and R&D), whilst executives were consulted regarding the usage of OI in their firms as well as their overall

perception of the potential of OI. Please see appendix 11 for the questionnaire on Corporate Strategy; appendix 12 for the questionnaire on HRM; appendix 13 for the questionnaire on Innovation and R&D; and appendix 14 for the questionnaire conducted to the professional executives.

4.1 Impacts of OI in the Corporate Strategy of Supply Chains

Upon the initial adoption of OI a firm may experience the disruption of normal processes given the paradigm-shift conveyed by OI. It is therefore vital for the firm's leadership to first implement a corporate strategy which will actively seek to minimize any disruption as well as to secure a smooth transition of processes. Moreover, OI may require the firm to further modify its corporate culture as a part of its overall strategy. This is as employees might have to adapt to a new corporate environment, with accordance to the intensity of the undertaken OI initiatives. It should be noted that, in the case of supply chain companies, the disruption of normal processes in one firm may hamper the overall efficiency of the supply chain, at least during the firm's adaptation and transition of corporate strategy and/or culture.

To successfully transition the corporate culture of a supply chain company to one which is more embracive of OI, it is imperative for the company's leadership to have a clear and unambiguous vision for the whole firm. Additionally, it is important to create a sense of co-ownership of projects across departments or with external partners across the supply chain. Focus should be on creating or otherwise improving communication paths for better dialogue and dissemination of knowledge both at an internal level, amongst departments; managers and employees, and along the immediate supply chain partners. In essence, employees should view external supply chain collaborators as an extension of the company which helps add and drive value, as opposed to separate or even competing entities. As such, one of the hardest strategic

challenges for supply chain companies who embrace OI is to reach the right balance of external collaboration (too much collaboration with supply chain partners may lead to an external dependency whilst not enough collaboration may undermine the benefits of OI).

A further challenge in deeply altering a company's strategy relates to the company's ability to address new and unexpected problems. OI in supply chains often relies on external partnerships for co-development of projects or utilization of external technology. As such, supply chain companies adopting OI initiatives in their strategy must be able to handle the legal risks which might arise from IP sharing or IP violations. It should be noted these risks are not homogeneous amongst companies, as smaller companies are less likely to have a structured and effective approach to dealing with corporate law.

4.2 Impacts of OI in Human Resource Management of Supply Chains

The impacts OI may have in the employee structure of a firm are relatively straight forward. Perhaps the most obvious example would be the effects on R&D departments, given that OI may diminish the need for internal R&D. This may be reflected internally in the downsizing of R&D departments, or otherwise, in a decrease in the total number of R&D employees in the supply chain. OI further implies R&D departments become more based on idea analysis rather than idea generation, thus requiring a different skill set mix from R&D employees. Another example is the growth of Law departments given the expected increase in intellectual property (IP) sharing throughout the supply chain. Nevertheless, OI may have multiple other impacts on Human Resources, both at the firm level and in the supply chain as a whole, which extend well beyond the regular scope of R&D and Law departments.

Currently, one of the main trends in HRM is the exacerbation of the "war for talent". This has been largely caused by shifts in social; demographic and technological factors such as an ageing population; work-life balance; globalization and ICT's. Such shifts have

highlighted and reinforced the need for human talent acquisition, especially in areas where skilled workers are undersupplied. In supply chains, however, OI may undermine this trend given that collaboration in the supply chain network may lead to the sharing of human talent and/or resources. Nonetheless, OI may also increase the employee turnover rate given the added connections to external projects and firms along the supply chain as well as internally due to cross-department mobility, thus potentially reinforcing the "war for talent" trend.

Moreover, and as discussed previously, OI may require companies to adapt their corporate strategy and culture. Such changes may cause power shifts inside the firm; alter inter-personnel relationships; impact employee career progression and incentives as well as future skill acquisition. Major shifts in a company's culture and strategy may therefore result in poor employee cultural adjustment or otherwise result in inefficient labor dynamics if executed improperly. Changes are often seen unfavorably by employees, unless they aim to decentralize or otherwise allow more autonomy in decision making and less hierarchical constraints for employees.

4.3 Impacts of OI in traditional innovation and R&D in Supply Chains

The impacts OI may have on traditional innovation and R&D processes may be drastic, depending on how relevant becomes the adoption of OI and given the inevitable disruption of traditional R&D processes when initially adopting OI. Whilst OI allows to find innovative solutions by exploring a larger "solution space" external to the firm, doing so may be harmful for two reasons: 1 - the gap between acquired knowledge and operational knowledge may be too great to overcome, rendering some innovations potentially redundant (though these may be sold, allowing for some commercial benefit); 2 - external collaborations may induce the company in losing control over their agenda, in terms of which solutions best fit their constraints and capabilities, thus causing the firm to lose adherence to its main strategy. As a

consequence, and in spite of allowing for a large “solution space”, the disruption of tradition R&D processes caused by OI may lead to more exploratory and less functional innovations.

Perhaps one of the greatest disruptions caused by OI in R&D departments regards the mind shift R&D employees must face. In essence, R&D departments have traditionally operated under a three step process concerning the (1) idea generation; (2) idea evaluation and (3) idea implementation. OI will often allow for the outsourcing of step 1 and 3, which indirectly stresses a renewed sense of importance for R&D departments to focus in evaluating which ideas are the most promising and suitable for the company to pursue. Therefore, OI might imply analytical skills become more important relative to creative skills. Furthermore, OI may exert a downward pressure on the budget allocated to R&D departments, given how external knowledge exploitation or acquisition is often associated with lower costs than knowledge creation or invention. This could further pressure the downsizing of R&D departments (as mentioned previously as a HRM impact).

4.4 Executives’ OI experience and perception

This section is based on the results of a questionnaire conducted to eight professional executives who work in seven different firms located in Portugal (two executives work in the same firm). Given the low amount of answers and the fact that the seven firms operate in different industries, these results may not accurately represent the penetration and utilization of OI in Portugal. The results are divided into three parts: 1- Characteristics of the executive’s firms regarding the use of OI; 2 - Executives perception of OI utilization; 3 - Executive’s classification of statements. Part 1 regards the actual usage of OI by the firms the executives work in. Part 2 is solely based on the perception the executives have of general OI utilization. Part 3 is based on the average classification the executives awarded each statement. Please see appendix 15 for the personal details (name; position and company) of each executive.

4.4.1- Characteristics of the executives' firms regarding the use of OI

The most relevant findings of part 1 of the questionnaire regard the fact that:

Table 3: Characteristics of the executives' firms regarding the use of OI

Characteristics of the executives' firms regarding the use of OI (Total nº of firms = 7)	
Firms usage of OI over time:	- Out of the 7 firms surveyed, 3 currently use OI. 1 firm used OI in the past but has since abandoned it
Duration of OI initiatives:	- Two firms use OI for more than 10 years - Two firms use OI between 1 to 2 years
Continuity of OI:	- Only one firm has used OI continuously since their first OI initiative
Evolution of OI intensity/prevalence:	- Two firm have experienced increased prevalence/intensity of OI - One firm has experienced decrease prevalence/intensity of OI - One firm has experienced constant prevalence/intensity of OI
Evolution of OI expenditure:	- One firm decreased expenditure in OI significantly - One firm has remained the same with regards to expenditure
Main benefits of OI:	- Improvement of overall business model/strategy - Better quality/performance of ideas generated - Beneficial partnerships/collaborations with external parties
Main drawbacks of OI:	- External collaborators fail to have an adequate sense of importance, urgency and/or priorities - Difficult to monitor and manage external project/ideas - Lack of time/cost effectiveness in implementing generated projects/ideas

Please see appendix 16 for more details regarding the executives' answers to part 1 of the questionnaire.

4.4.2 - Executives' current perception of OI utilization

The most relevant findings according to the executives' current perception of OI are:

Table 4: Executives' current perception of OI

Executives' current perception of OI utilization (Total nº of executives = 8)	
Where can OI be most useful?	R&D; Operations & Logistics; IT
Where would OI be the most disruptive?	R&D; Operations & Logistics; Strategy
What sectors are best for OI?	5 executives say Manufacturing; 3 executives say Services
What sectors are worst for OI?	2 say Manufacturing; 3 say Services; 2 say Hybrids; 1 says Distribution
Executive's perception of OI utilization according to company size:	Large firms - 32.3% Medium firms - 17.3% Small firms - 11.4% Start-up firms - 58.6%
The 5 most important characteristics for OI:	1 - A risk-taking managerial mindset 2 - A collaborative corporate culture 3 - An agile/adaptive corporate strategy 4 - Strong corporate leadership 5 - Existence of knowledge disseminating/facilitating mechanisms

Please see appendix 17 for more details regarding the executives' answers to part 2 of the questionnaire.

4.4.3 - Executives' classification of statements

The following statements were graded from 1 (completely disagree) to 9 (completely agree) by the eight executives. The value of each statement is therefore an average of the grades given by the eight executives. The statements with the three highest grade averages were (the average grade appears in brackets at the end of each statement):

- Statement nº 2 - The potential advantages of Open Innovation outweigh the potential disadvantages (7.88/9)
- Statement nº 1 - Open Innovation is a high impact trend which will increasingly become widespread in the future (7.50/9)
- Statement nº 5 - Companies engaging in Open Innovation are more likely to be successful than companies that don't (7.13/9)

The statements with the three lowest grade averages were (the average grade appears in brackets at the end of each statement):

- Statement nº 4 - Implementing Open Innovation initiatives tends to be simple; easy and straight-forward (3.38/9)
- Statement nº 12 - Corporate collaborations between firms in radically different markets are unlikely to be efficient and should be avoided (3.63/9)
- Statement nº 8 - Open Innovation initiatives should be conducted in a centralized manner (3.63/9)

Please see appendix 18 for more details regarding the executives' answers to part 3 of the questionnaire.

5 - General future of OI and its application in SCM

A 2013 executive study conducted by UC Berkeley and the Fraunhofer Society to large firms in US and Europe (firms with over 1000 employees and more than $250 million in sales), found that 78% of firms practiced some form of OI in 2013 (Chesbrough & Brunswicker, 2013). None of them had abandoned OI since first undertaking it, with the median firm having 5 years' worth of OI experience. Furthermore, 71% of firms supported

management employees in adopting OI and 82% of firms showed signs of increasing OI activity.

Using the same firm criteria, a follow-up study in 2015 conducted by UC Berkeley and Purdue University found that approximately 78% of firms practiced some form of OI in 2015. Only 2.5% of firms had abandoned OI whilst 61% increased financial investment in OI (of which 22% of firms increased OI investments by more than 50%) (Chesbrough & Brunswicker, 2015). However, 72% of firms spent less that 20% of the total innovation expenditure in OI (see table 5). The study further found a 5% median of firms' projects which freely shared their knowledge with external partners, whilst there was a 20% median for firms' projects which freely accessed external knowledge. This seems to indicate that large firms use inbound OI more than outbound OI (Chesbrough & Brunswicker, 2015). Additionally, there seems to be an indication that projects implemented under freer access to knowledge tend to be more successful (69% of successful projects have selective or no legal ownership rights, whilst 54% of unsuccessful project have selective or no legal ownership rights) (Chesbrough & Brunswicker, 2015).

Table 5: OI in large European and US firms

OI in European and US firms (with >1000 employees and $250 million in sales)		
	2013	2015
OI Adoption	78%	78%
OI Abandonment	0%	2.5%
OI experiecnce	median of 5 years	N/A
OI Management Support	71% increased management support	N/A
OI Intensity	82% increase OI activity	N/A
OI Financial Support	N/A	61% increased financial investment (22% by more than 50%)
OI Expenditure	N/A	72% spend less that 20% of total innovation expenditure in OI
OI Human Resources	N/A	53% have more than 5 full-time employees working in OI

Table constructed by the author based on (Chesbrough & Brunswicker, 2013) (Chesbrough & Brunswicker, 2015)

Furthermore, OI implementation has thus far shown to be seriously affected by 3 contexts: (1) the industry; (2) the degree of competition and (3) manufacturing vs. services (Gassmann, Enkel, & Chesbrough, 2010). Industries where the business model is mainly based on B2B (e.g: chemical industry), including in supply chains, have shown difficulties in IP protection under OI. In these cases OI usually takes the form of a joint project and collaborations with suppliers; academia or research institutes (Raja & Sambandan, 2015). Industries with high levels of competition and great technological intensity (e.g: mobile-phone industry) have shown some reluctance in using external OI in the form of partnerships with competitors (Chesbrough, 2005). In these cases OI is mainly conducted internally or using customers and suppliers as the main source of innovation, though other examples of OI include reverse engineering; collaborative research projects with non-competing firms; scouting, funding and acquisition of start-ups. Service industries have shown a tendency to outsource R&D and insource technology, using consumers as their main source of innovation, whilst manufacturing industries (being more technological intensive) have focused more on IP in-licensing and external technological acquisitions (A.Paton & McLaughlin, 2008).

Additionally, the primary data collected for the purpose of this paper supports the growth of OI as a seemingly cross-industry trend. The input given by experts and especially the questionnaires conducted to professional executives resulted in quantifiable indicators which further reinforce the idea that OI has a future. Regarding the executives answers, part 2 and 3 of the questionnaire indicate that executives perceive OI as an important mechanism for firms to interact with. Particularly part 3 seems to specify that, generally speaking, executives see significant potential in OI given the 3 statements with the highest average grade value.

Specifically regarding SCM, OI is expected to continue to be a force and mechanism which can aid the streamline process in supply chains (Torres & Ibarra, 2015). Certain macro-

trends (such as the technological upsurge of inexpensive high speed communication tools; the rise of digital products and shorter PLC) imply that OI will increasingly become a part of SCM (EPSC, 2018). The increase intricacy and complexity of global production systems require increasingly flexible and adaptive solutions to meet market demands (Enkel & Gassmann, 2010). Leveraging the know-how of supply chain partners, both in and across the supply chain tiers, is likely to be an inalienable part of the solutions for the challenges supply chains will face in the future (Zamboni, 2011).

6 – Conclusion

This paper has set out to answer both questions present in section 1.1, and in doing so it evaluated the application of OI in supply chains. OI presents a R&D and corporate strategy paradigm shift in which a company should use both internal and external ideas and internal and external market paths to advance their technology (Chesbrough, 2005). Currently, OI has been established in supply chains mainly via integration of supplier inputs at early stages of the PLC as sources of innovation (Anne-Laure Mention, 2016). The leveraging of suppliers know-how as a source of innovation is empirically linked with certain benefits and KPI's improvements in existing literature (Bigliardi & Bottani, 2010). However, although OI has been present in SCM via supplier integration the same is less visible in customer integration, and as a result, it seems clear that upon the initial introduction of OI in supply chains, OI is best applied by reinforcing supplier interactions. Nevertheless, establishing customer integration can be a form of differentiation in an increasingly dynamic market, where customer buyer values are less consistent (mainly due to a faster technological cycle and a shorter PLC) (EPSC, 2018). Caution is necessary when applying OI in SCM given that one of the main characteristics of "lean" production systems regards a stable and efficient relationship between different actors in the supply chain. OI may hinder the stability and

efficiency of well-established supply chain relationships, which therefore implies the key challenge to properly apply OI in SCM is the implementation speed and the stability of any newly formed relations (Aziz, Mahadi, & Mahadi, 2017).

The risk of disrupting well-established relations seems to create a conflict between supply chains' search for stability and OI implementation. However, in its simplest terms, the nature of OI does not seem to be contrary to that of supply chains for two reasons: 1 - Supply chains already rely on cooperation with external partners (mainly suppliers) as means to achieve an efficient and streamlined supply chain process as well as a source of innovation. 2 - The utilization of OI in SCM is, in a way, an evolution the "lean" production systems, and therefore OI utilization is a partially natural formed trend in supply chains (Anne-Laure Mention, 2016). Based on this, and given the increase in other macro-trends (such as technological improvements and shorter PLC), it appears likely that OI will play an increasingly important part in SCM (EPSC, 2018). Furthermore, relevant literature, as well as the questionnaires conducted in section 4, supports the notion that OI is a beneficial and high impact trend which firms should seek to engage with. It seems clear how SCM under the OI mindset will consequently be a force for increased supply chain integration whilst expanding partner participation across the whole product conception process (McMahon, 2015).

Finally, OI may further cause innovation budget allocation shifts in supply chain firms, which will possibly present HRM consequences. This is as R&D departments will likely start experiencing a transition of being closely attached to the development of innovative ideas and processes into an idea-analysis framework. Under OI, R&D departments will become increasingly responsible for analyzing ideas and process concepts obtained from outside the company, thus implying these departments will become more managerial and analytical as opposed to creative, which therefore alters the skill-mix of R&D department employees.

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8 – Appendix

Appendix 1 – Inbound and Outbound OI

Inbound OI regards the usage and internalization of external knowledge by the firm. In essence, inbound OI implies that there is no need for a company to rely solely on their R&D given that solutions and inventions may be retrieved from outside the company (Chesbrough, 2005). As an example, consider how Apple benefited from the App Store (a developing platform where people could actively create and sell apps at no additional expense to Apple). Apple did not have to create all the apps in the App Store, whilst each additional app created and made available in the App Store ultimately added value to Apple products.

Outbound OI regards the externalization of internal knowledge by the firm, often as means to access an external market path. Rather than relying solely on internal paths to commercialize an invention, firms may use more suitable external market paths to access a given market or even sell the invention altogether (Chesbrough, 2005). It is common for outbound OI to involve licensing agreements or spin-offs, though other forms of outbound OI can be based on open business models where the goal is simply to make internal knowledge available for all users.

Inbound and outbound OI therefore refer to the flux direction of knowledge being transferred. The distinction allows to evaluate the way in which OI occurs, either by knowledge importation or exportation by the firm. Note that both inbound and outbound OI are not mutually exclusive as that will most likely depend on the type of business model in question. For example, the model used by the Wikipedia Foundation on Wikipedia relies on both inbound OI (from having Wikipedia users develop Wikipedia articles) and outbound OI (by making Wikipedia articles freely available to any user).

Appendix 2 – Visual illustration of the Closed Innovation Model

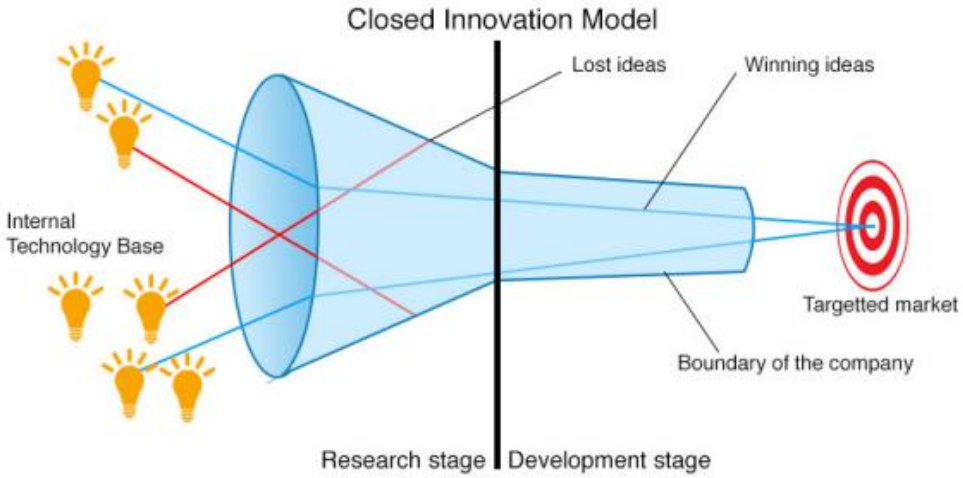

Figure retrieved from (Elmansy, 2015)

Appendix 3 – Visual illustration of the Open Innovation Model

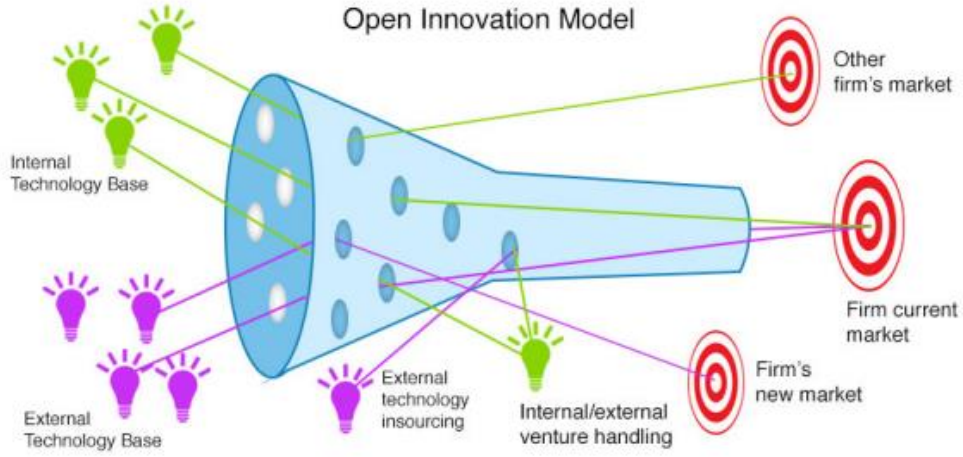

Figure retrieved from (Elmansy, 2015)

Appendix 4 –Principals of OI vs. CI

Principals of OI vs. CI	
OI Principals	CI Principals
Tap into external knowledge sources outside the firm-level to complement and improve upon the firm's existing knowledge	The existing knowledge sources inside the firm are sufficient to meet the firm requirements and needs
External innovations create massive value; internal innovations assure a portion of that value	Profit due to innovations is discovered; developed and marketed only internally
Focus on using the best internal and external ideas	Focus on having the most and best ideas
Profits can be made by others using our IP; we should buy others IP when it advances our business model	Control of IP prevents competitors from profiting from our ideas
Having a better business model is key	Entering the market first is key

This table constructed by the author, based on (Chesbrough, 2003)

Appendix 5 –The Centralized and Decentralized OI model

Open Innovation with central agent (centralized OI): In this model, the firm sets strategic partnerships with external parties (e.g: other firms; universities; etc.). These parties have no connections amongst themselves other than the link their share in common with the firm, thus making the firm the central agent in this model. This way, if the firm were to leave the model, there would no longer be anything holding the external parties together and the model would break apart (Knoke, 2005).

Open Innovation with a central agent

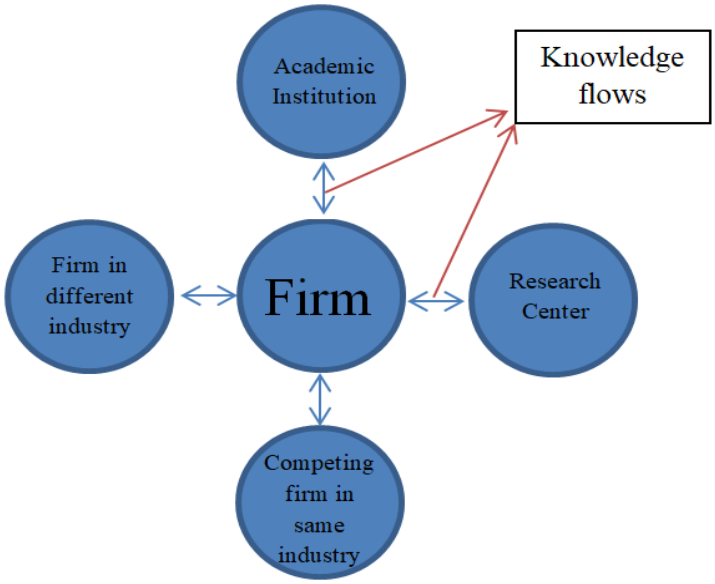

Figure constructed by the author

Community Based Innovation Model (decentralized OI): Under the community based model, the firm is only another member in a collaborative community. This community shares information and knowledge amongst themselves for the benefit of the community as a whole. Each external party may be connected to the firm or to a party other than the firm. This way, even if the firm were to leave this community, the community would continue as the firm doesn't act as a central agent keeping the community unified (Knoke, 2005).

Community Based Innovation Model (decentralized OI)

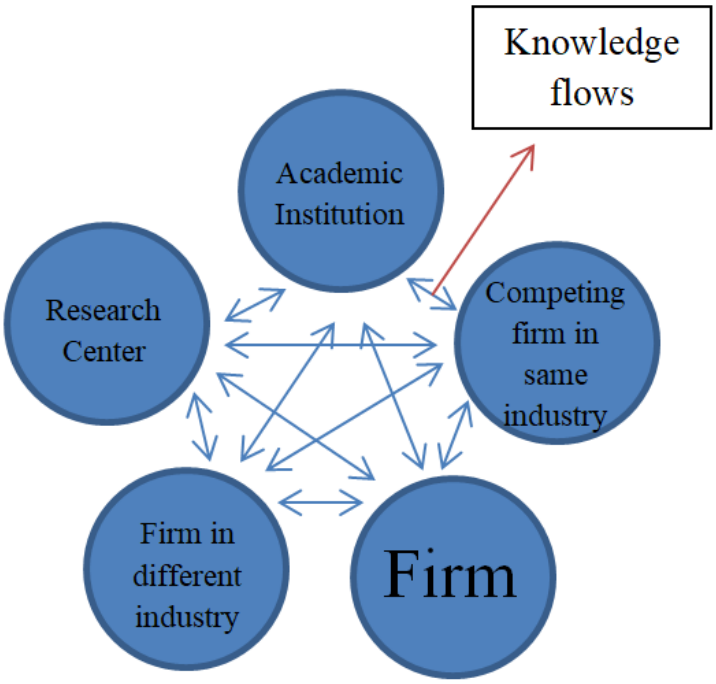

Figure constructed by the author

Appendix 6 – OI Knowledge exploiting mechanisms

Firm interactions with OI have appeared in many forms (see appendix 7 of OI techniques). However, in order for a firm to efficiently harness the benefits of OI there needs to be a mechanism of knowledge exploitation first put into place. For the most part, most practices can be classified as being linked to one of the following knowledge exploiting mechanisms (Chesbrough, 2003):

- Intellectual Property (IP): In essence, IP works as a type of OI currency where under a regulatory framework companies wishing to use a certain invention or knowledge source must do so in a restrictive manner. Under OI, trading of IP allows firms to gain additional revenue from their knowledge base without losing control over it or otherwise fearing competitors appropriating the invention.

- Venturing: Venture allows for a less ridged corporate structure when it comes to R&D and can take multiple forms (e.g: selling a firm division; use venture capital to acquire smaller firms; etc.). Venturing can therefore be used as a mechanism to either internalize existent external knowledge to the firm (usually via M&A or other formal corporate partnerships) or by increasing profits by selling projects which the firm will not undertake or otherwise complete.

- Network of Collaboration: In this case, OI can be applied by using a formal/informal community or network of collaborators which facilitates the flow of knowledge. These can be undertaken at an internal or external level to the firm and may or may not be digitally based using an online platform. These networks can therefore take a wide variety of forms (such as industry consortiums; alliances; online community clusters of employees/experts; etc.) and may be used in practically any stage of the innovation development process, from the idea generation up to the implementation and feedback.

Appendix 7 - OI Techniques

There are multiple strategies a firm may wish to deploy when undertaking an OI initiative (see the table below). These strategies differ with accordance to the type of OI (if inbound or outbound) as well as the overall OI goal or chosen OI mechanism and technique of the firm (Torres & Ibarra, 2015). OI goals and mechanisms vary greatly (e.g: sharing knowledge for free vs. selling it for a price), and therefore it is imperative for the firm to correctly assess its needs and requirements before committing to a particular OI strategy (Piller, 2013).

Main OI Techniques		
OI Technique	Outbound OI	Inbound OI
Community-building	Knowledge sharing; Open source; Free revealing	Open source; Crowdsourcing; User communities
Facilitation	Intermediaries; Role of IT	Intermediaries; Role of IT
New Revenue Stream	Spin-offs; Exploit internal knowledge externally; Corporate venturing; Corporate incubator	N/A
Complement	Lincensing-out	Licensing; IP; M&A; Exploration/exploitation; External technologies; Internal leveraging on external ideas
Sourcing	Market search	External knowledge access; reverse engineering
Collaboration	Joint-ventures; Value/supply chain collaboration; Networking; Academia/research institutes; Strategic alliances	Joint-ventures; Value/supply chain collaboration; Networking; Academia/research institutes; Strategic alliances

Table constructed by the author based on (Juan Igartua, 2010) & (Knoke, 2005)

Appendix 8 - The Nine Firm Perspectives of OI

The success or failure of any innovation program or initiative will always be affected by varying dimensions regarding any particular innovation related issue a firm may face (Haner, 2002). Specifically, there are nine main different perspectives which are likely to shape the way in which a firm choses to undertake OI, and which will therefore help the firm define the best OI practices to be developed (Gassmann, Enkel, & Chesbrough, 2010).

Perspective	Focus Defenition
Spatial Perspective	Geographical location (of assets; markets; stakeholders; factories; etc.)
Strucural Perspective	The industry structure; value chain and network between all different actors (producers; suppliers; customers; end-users)
User Perspective	The ability to incorporate end-users and suppliers as innovation sources in the innovation process, allowing for better management of their needs; requirements and feedback
Supplier Perspective	The ability to incorporate suppliers as innovation sources in the innovation process, allowing for better management of their needs; requirements and feedback
Leveraging Perspective	The maximization of benefits from existing assets via marketing or business model innovation - related to use of IP in OI
Process Perspective	The type of OI paradigm which best suits the firm in terms of benefits and practicability
Tool Perspective	The tools necessary for OI implementation. Either in terms of digital or physical tool kits
Institutional Perspective	The balance between the firm's property and public knowledge and how the firm may best harness both to its benefit
Cultural Perspective	Corporate aspects intrinsic to the firm such as its culture; mindset; organization; structure; etc.

Table constructed by the author based on (Gassmann, Enkel, & Chesbrough, 2010)

Appendix 9 - Advantages and Disadvantages of OI

Advantages and Disadvantages of OI	
Advantages	Disadvantages
Potential reduction of time and cost of generating innovation projects	No guarantee that generated projects will be cost and time effective when implementing
Access to ideas; patents; products; solutions and inventions which the company could otherwise not have access to	Hard to define which projects allow for the greatest return on investment
Commercialization of inventions unused or otherwise not placed in the market due to strategy/time/cost or other reasons	Hard to define which metrics are suitable to measure the quality of innovation projects
Synergies may be found in problems with potentially similar solutions	External collaborators are likely to not have the same sense of urgency and importance regarding innovation projects
Can lead to mutually beneficial long-term partnerships	Organizational culture/behavior; R&D issues; Business model and IP policy may all harm the effectiveness and usefulness of OI
OI allows for the risk-spreading of the innovation process	There can be difficulties associated with sharing IP rights with external partners
Increase in the probability of finding useful knowledge to the firm (both internally and externally)	A too great amount of ideas and partners can be counter-productive due to poor management and monitoring. The best ideas and partners may be overlooked or otherwise not given the right amount of attention as a consequence
Increase in the amount of ideas and innovations generated	Too much simultaneous absorption of knowledge from multiple sources may be inefficient given a potential knowledge absorption "saturation level"
Helps break down "silo" vision by increasing the number of knowledge sources (both internally and externally)	May be of limited use in cases where the problems require the understanding of a specific knowledge area (often called "sticky" information, as the information is hard to disseminate). Accurately conveying the problem to external sources may be dependent on external understanding of language used ("sticky" information is usually due to "sticky" language). E.g: problems in areas such as IT; Medicine; Mathematics; etc.

Table constructed by the author based on (André Ullrich, 2016) and (Lichtenthaler, 2011)

Appendix 10: Collaborative Resource Utilization in Supply Chains

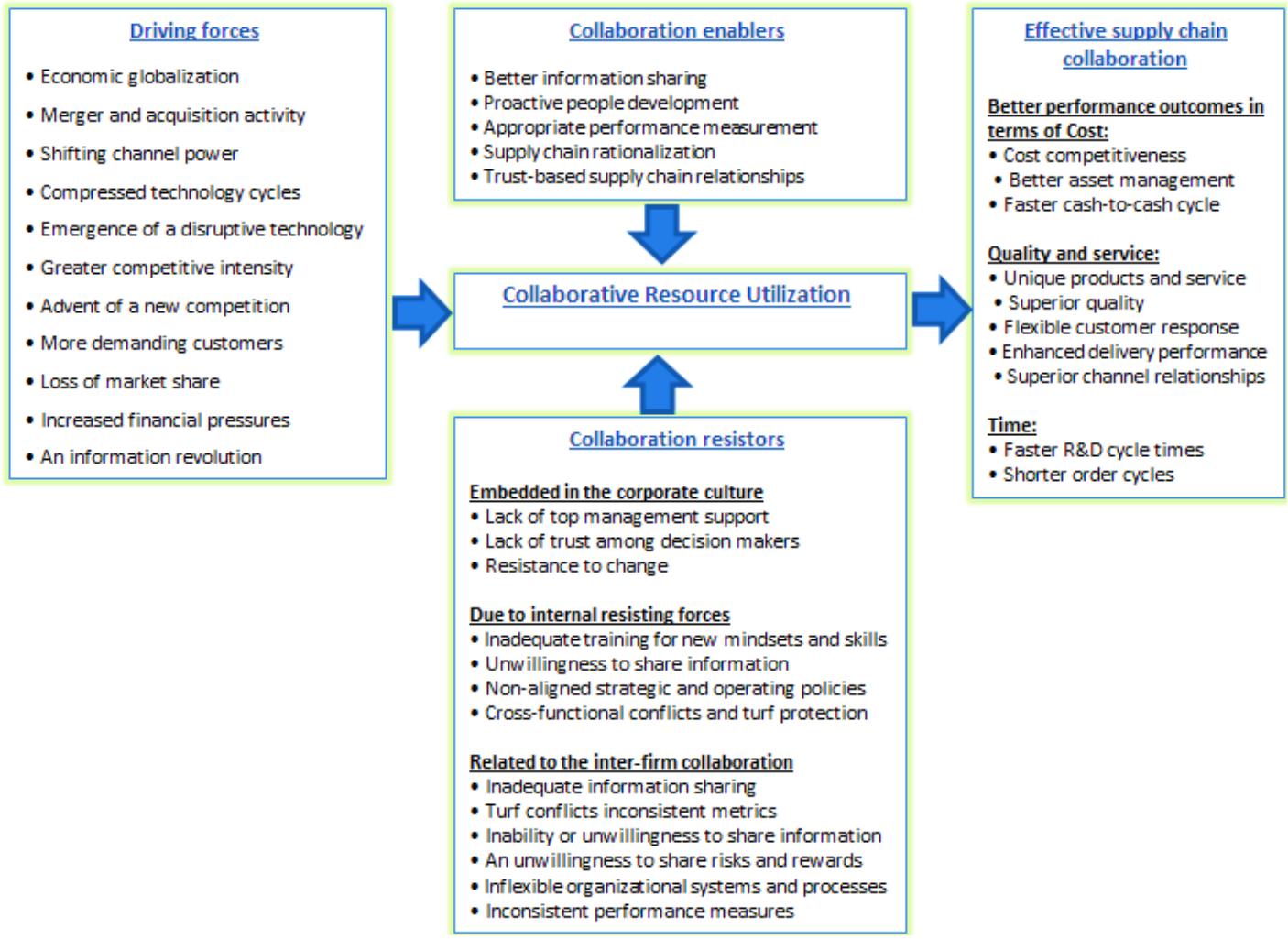

Chart constructed by the author, retrieved from (Zamboni, 2011)

Appendix 11: Questionnaire on Corporate Strategy

Two university professors at Nova School of Business and Economics responded to the Corporate Strategy questionnaire. Expert *A* is an Associate Professor at Nova who specialized in Strategic Management, Managing International Strategic Alliances and International Business. He has experience in research areas such as Strategic Agility, Strategic Alliances and Product Service Innovation. He is also a member of multiple scientific research associations including the Academy of Management. Expert *B* is an Associate Professor Adjunct at Nova as well as Academic Director of the CEMS MIM program. He has professional experience working in the Royal Philips Electronics and as a strategy and management consultant for the Portuguese Society for Innovation. His research interest includes Complex Adaptive Systems and Innovation.

Interview Subject: Corporate Strategy

Question 1: How have information and technological advancements altered traditional corporate strategies regarding R&D?

Question 2: What are the main strategy-related challenges and risks regarding changes in the traditional R&D process of a firm?

Question 3: Generally speaking, how can changes in a firm's corporate strategy and culture best be implemented?

Question 4: Generally speaking, what would you recommend for better knowledge dissemination and communication across a whole company (internal "Open Innovation")? What about with external partners (external "Open Innovation")?

Question 5: Of the following options, explain which one(s) you consider to be the greatest challenge(s) to "Open Innovation" at a firm level? 1- Organizational culture; 2- Business Model; 3-IP Policy; 4-Other (please specify)

Question 6: What foreseeable risks could result from the application of "Open Innovation"? Are the risks similar across companies (Start-ups; Multi-nationals Corporations; local businesses; digital businesses; etc.)?

Question 7: In what specific areas do you think Open Innovation could be most useful (e.g: supply chain management; operations and logistics; human resource management; digital businesses; etc.)?

Question 8: What foreseeable risks could be expected if firms become too reliant on external collaborations?

Question 9: Generally speaking, what are the main advantages and disadvantages of having a "boundless" organizational structure?

Appendix 12: Questionnaire on Human Resource Management (HRM)

Two university professors at Nova School of Business and Economics responded to the HRM questionnaire. Expert *C* is an Associate Professor of Human Resource Management at Nova, having a M.A degree in Human Resource Management and a PhD. in Management. She has multiple publications in various academic journals including the International journal of HRM and the Journal of Organizational Change Management. Her main interest of research includes the impacts of HRM on organizational performance. Expert *D* is an Assistant Professor Adjunct at Nova. She has a M.A in Social and Organizational Phycology and a PhD. in Management, Organizational Behavior. She also has multiple publications in various academic journals including the Journal of Managerial Phycology and the Journal of Vocational

Behavior. Her main research fields are organizational behavior and industrial/organizational phycology.

Interview Subject: Human Resource Management

Question 1: In general, what are the main HR impacts that can be expected by major shifts in corporate culture?

Question 2: Currently, what are the most significant trends in Human Resource Management? Can the speed of change in any of those trends be amplified by “Open Innovation”?

Question 3: How has technological advancements altered traditional HRM dynamics?

Question 4: What foreseeable HRM risks could result from the application of “Open Innovation” and how could these risks be minimized? Are the risks similar across companies (Start-ups; Multi-nationals Corporations; local businesses; etc.)?

Question 5: What would you recommend for fast knowledge dissemination across the whole company (internal “Open Innovation”) and with its external partners (external “Open Innovation”)?

Question 6: What are the most critical HRM elements for a successful implementation of an Open Innovation strategy at a firm level (e.g: strong leadership; collaborative culture; good communication; team building; adequate performance metrics; etc.)?

Question 7: Generally speaking, what type of HRM impacts regarding R&D departments can be expected if Open Innovations adaptation becomes mainstream (e.g: smaller/larger number or workers; smaller/higher turnover rate; etc.)?

Question 8: What type of HRM impacts specifically regarding Supply Chain Management may be expected if Open Innovations adaptation becomes mainstream?

Appendix 13: Questionnaire on Innovation and R&D

Three Nova School of Business and Economics professors responded to the Innovation and R&D questionnaire. Expert *E* is an Associate Professor at Nova with professional experience in various advisory and executive roles and having also worked as a telecommunications engineer. At Nova he teaches an Open Innovation course. He has a dual PhD. degree in Strategy, Entrepreneurship, and Technological Change as well as Masters Degrees in Engineering and Public Policy, and in Information Technology. His main research interests include Open and User Innovation, Technology Strategy and Data Science. Expert *F* is an Associate Professor (Affiliate) at Nova as well as the Head of the Center for Digital Business and Technology. He holds a PhD. from the Massachusetts Institute of Technology and following his PhD. he spent a short time as a post-doc with the Center of Design Research at Stanford University. His professional work experience includes working with disruptive innovation, digital transformation, new business models and products. His main research topics include digital transformation, innovation management, design thinking and product design and development. Expert *G* is part of the Adjunct Faculty at Nova. He has vast professional experience in Senior Management and Board positions in multiple industries such as Banking, Urban Transportation, FMCG, Modern Retail and Telecommunications. His main research interests regard Strategy, Strategic Planning, Innovation and Entrepreneurship and the Development of Future Scenarios.

Interview Subject: Innovation/R&D

Question 1: Historically speaking, what were the main strategy-related challenges and risks in the traditional R&D innovation process of a firm (before mainstream adaptation of Information Communication Technologies)?

Question 2: Logistically speaking, what tends to be the main types of limitations firms currently have regarding innovation? What are the main challenges in the current R&D innovation process?

Question 3: What foreseeable risks could result from the application of "Open Innovation"? How can these be minimized?

Question 4: What are some critical elements for a successful implementation of Open Innovation at a firm level (e.g: strong leadership; collaborative culture; good communication; team building; adequate performance metrics; etc.)?

Question 5: Would you consider Open Innovation as a potential high-impact trend for the future of R&D?

Question 6: What type of impact in current R&D departments can be expected if Open Innovations adaptation becomes mainstream (e.g: smaller number or workers; decrease budget; decrease importance; etc.)?

Question 7: In which specific areas do you think Open Innovation could be most useful (e.g: supply chain management; operations and logistics; human resource management; digital businesses; etc.)?

Question 8: How can Open Innovation best be applied to supply chains?

Appendix 14: Questionnaire for Professional Executives

Part 1

Question 1: How large is the firm you are currently working in, or the previous firm you worked in for at least 3 years? (Please select one)

1 – 1 to 9 employees 2 – 10 to 49 employees

3 – 50 to 99 employees 4 – 100 to 199 employees

5 – 200 to 399 employees 6 – 400 to 999 employees

7 – 1000+ employees

Question 2: Is such firm currently engaging with some form of Open Innovation initiative? (Please select one)

1 – Yes 2 – No 3 – Don't Know

Question 3: Has such firm engaged with some form of Open Innovation initiative in the past? (Please select one)

1 – Yes 2 – No 3 – Don't Know

Question 4: For how long has such firm engaged with Open Innovation? (Please select one)

1 – N/A 2 – For less than 1 year

3 – Between 1 to 2 years 4 – Between 2 to 5 years

5 – Between 5 to 10 years 6 – For more than a decade 7 – Don't Know

Question 5: Has such firm abandoned using Open Innovation since first engaging with it? (Please select one)

1 – Yes 2 – No 3 – Don't Know 4 – N/A

Question 6: Has such firm continuously used Open Innovation initiatives since first engaging with it? (Please select one)

1 – Yes 2 – No 3 – Don't Know 4 – N/A

Question 7: How would you describe the evolution of Open Innovation related activities in such firm? (Please select one)

1 – They have become more intense/prevalent since first using Open Innovation

2 – They have become less intense/prevalent since first using Open Innovation

3 – They have remained more or less the same with regards to intensity/prevalence

4 – N/A

Question 8: How would you describe the evolution of such firm's investment/expenditure in Open Innovation related activities? (Please select one)

1 – N/A 2 – It increased significantly

3 – It increased marginally 4 – It has neither increased or decreased

5 – It has decreased significantly 6 – It has decreased marginally

7 – Don't Know

Question 9: How many employees in such firm work in Open Innovation related activities? (Please select one)

1 – 1 employee 2 – 2 to 5 employees

3 – 6 to 9 employees 4 – 10 to 19 employees

5 – 20 to 49 employees 6 – 50 + employees

7 – N/A 8 – Don't Know

Question 10: How would you describe the majority of employees working in Open Innovation related activities in such firm? (Please select one)

1 – Majority full-time employees

2 – Majority part-time employees

3 – An even mixture of full-time and part-time employees

4 – N/A

Question 11: What are the main benefits such firm has enjoyed from Open Innovation related activities? Please select up to 5 options and attribute a level of impact from 1 (very low) to 9 (very high)

LEVEL OF IMPACT	BENEFITS
	1. Reduction in R&D costs
	2. Faster innovation cycles
	3. Better quality/performance of ideas generated
	4. Alternative (external) paths to markets
	5. Access to external ideas; patents; products; solutions and/or innovations
	6. Improvement of overall business model/strategy
	7. Decrease in time/cost/strategy related constraints
	8. Maximization of firm potential and/or synergies
	9. Beneficial partnerships/collaborations with external parties
	10. Risk spreading of the innovation process
	11. Other (please specify):_____

Question 12: What are the main drawbacks such firm has experienced from Open Innovation related activities? Please select up to 5 options and attribute a level of impact from 1 (very low) to 9 (very high)

LEVEL OF IMPACT	DRAWBACKS
	1. Lack of time/cost effectiveness in implementing generated projects/ideas
	2. Difficulties in defining which projects/ideas allow for greatest return on investment
	3. Difficulties in defining which metrics best measure quality of generated projects/ideas
	4. External collaborators fail to have an adequate sense of importance; urgency and/or priorities
	5. Difficult to share/gain/sell IP rights for ideas/technologies/projects
	6. Difficult to monitor/manage external project/ideas
	7. Increase in time/cost/strategy related constraints
	8. Difficulties in accurately conveying problem specifications to external collaborators
	9. Other (please specify): _____

Part 2

Question 13: In which specific corporate areas do you think Open Innovation initiatives could be most useful? (Please select one or more)

1 – R&D
2 – Consumer Support
3 – Finance
4 – Logistics/Operations
5 – Accounting
6 - HRM
7 – IT
8 – Marketing
9 – Strategy
10 – Other (please specify): _____

Question 14: In which specific corporate areas do you think Open Innovation would have the greatest impacts in terms of disrupting traditional processes (either for better or worse)? Please select up to 5 options and attribute a level of impact from 1 (very low) to 9 (very high)

LEVEL OF IMPACT	DRAWBACKS
	1. R&D
	2. Consumer Support
	3. Finance
	4. Logistics/Operations
	5. Accounting
	6. HRM
	7. Marketing
	8. Strategy
	9. IT
	10. Other (please specify):

Question 15: Which business areas do you consider to be best suited to benefit from Open Innovation initiatives? (Please select one)

1 – Manufacturing 2 – Services 3 – Distribution 4 – Hybrids

Question 16: What types of business areas do you consider to be least suited to benefit from Open Innovation? (Please select one)

1 – Manufacturing 2 – Services 3 – Distribution 4 – Hybrids

Question 17: Currently what percentage of overall firms do you believe engage with some sort of Open Innovation activities?

SIZE	% ENGAGED IN OPEN INOVATION
1. Large firms	_____%
2. Medium firms	_____%
3. Small firms	_____%
4. Start-up firms	_____%

Question 18: Generally speaking, what would you consider to be the 5 most important characteristics for the successful implementation of Open Innovation at the firm level? Please score the following from 1 (least important) to 5 (most important)

SCORE	IMPORTANT CHARACTERISTICS
	1. Strong corporate leadership
	2. A collaborative corporate culture
	3. A risk-taking managerial mindset
	4. Complex Logistics/Operations
	5. An agile/adaptive corporate strategy
	6. Efficient corporate processes
	7. Adequate provision/allocation of necessary resources
	8. Existence of knowledge disseminating/facilitating mechanisms
	9. Significant business integration with suppliers/vendors/clients
	10. Other (please specify):

Part 3

Question 19: Using a scale of 1 to 9 (where 1 stands for completely disagree and 9 stands for completely agree) please classify **all** following statements:

STATEMENT	LEVEL OF AGREEMENT
1. Open Innovation is a high impact trend which will increasingly become widespread in the future	
2. The potential advantages of Open Innovation outweigh the potential disadvantages	
3. Open Innovation is a trend which carries minimal risks	
4. Implementing Open Innovation initiatives tend to be simple; easy and straight-forward	
5. Companies engaging in Open Innovation are more likely to be successful than companies that don't	
6. Open Innovation is more useful as means of importing knowledge than exporting knowledge	
7. Open Innovation is more useful as means of knowledge sharing than in creating alternative paths to markets	
8. Open Innovation initiatives should be conducted in a centralized manner	
9. Firms should aim to adapt their strategy/behavior/business model in order to increase the benefits of Open Innovation	
10. Companies with rigid corporate structures are unlikely to successfully implement Open Innovation initiatives	
11. Improving existing corporate partnerships is more beneficial than creating new partnerships	
12. Corporate collaborations between firms in radically different markets are unlikely to be efficient and should be avoided	
13. External collaborations under no IP restrictions tend to be more beneficial than with IP restrictions	

Appendix 15: Personal Details of the Executives

Personal details of the Executives and their firms		
Name	Executive Role	Firm
Bernardo Macedo	Partner	Boyden
José Miguel Paredes	CFO	Semapa Sociedade de investimento e Gestão SGPS, SA
Miguel Ventura	Executive board member	Semapa Sociedade de investimento e Gestão SGPS, SA
Nuno Botelho	Head of Wealth Management	MillemniumBCP
Paula Nanita	Executive Board Member	FNSBS
Paulo Santos	Managing Partner	WiseNext
Pedro Simões	CFO	Unilever Fima
Manuel Godinho	ex-CEO	Glintt

Appendix 16: Executives' answers Part 1 - Characteristics of the firms' usage of OI

Characteristics of the executives' firms regarding the use of OI (Total nº of firms = 7)	
Size of firms (nº of employees):	- Three firms with more than 1000 employees - One firm with 400 to 999 employees - One firm with 50 to 99 employees - One firm with 10 to 49 employees - One firm with 1 to 9 employees
Firms usage of OI over time:	- Three currently use OI - Three have never used OI - One firm has used OI in the past
Firms abandondment of OI:	- One firm used OI in the past but not currently
Duration of OI initiatives:	- Two firms use OI for more than 10 years - Two firms use OI between 1 to 2 years - Three firms never used OI
Continuity of OI:	- Only one firm has used OI continuously since their first OI initiative
Evolution of OI intensity/prevalence:	- Two firms have experienced increased prevalence/intensity of OI - One firm has experienced decrease prevalence/intensity of OI - One firm has experienced constant prevalence/intensity of OI - Three firms never used OI
Evolution of OI expenditure:	- One firm decreased expenditure in OI significantly - One firm has remained the same with regards to expenditure - Six executives either don't know or is not applicable
Main benefits of OI:	- Improvement of overall business model/strategy - Better quality/performance of ideas generated - Beneficial partnerships/collaborations with external parties
Main drawbacks of OI:	- External collaborators fail to have an adequate sense of importance, urgency and/or priorities - Difficult to monitor and manage external project/ideas - Lack of time/cost effectiveness in implementing generated projects/ideas

Appendix 17: Executives answers Part 2 - Executives perception of OI

Executives' perception of OI utilization (Total nº of executives = 8)	
Where can OI be most useful?	- R&D - Operations & Logistics - IT
Where would OI be the most disruptive?	- R&D - Operations & Logistics - Strategy
What sectors are best for OI?	- 5 executives say Manufacturing - 3 executives say Services
What sectors are worst for OI?	- 2 say Manufacturing - 3 say Services - 2 say Hybrids - 1 says Distribution
Executive's perception of OI utilization according to company size:	Large firms - 32.3% Medium firms - 17.3% Small firms - 11.4% Start-up firms - 58.6%
The 5 most important characteristics for OI:	1 - A risk-taking managerial mindset 2 - A collaborative corporate culture 3 - An agile/adaptive corporate strategy 4 - Strong corporate leadership 5 - Existence of knowledge disseminating/facilitating mechanisms

Appendix 18: Executives answers Part 3 - Executives classification of statements

Executives classification of statements Range: 1 (completely disagree) to 9 (completely agree)	
Statements	Average of 8 classification (where 1 is the minimum and 9 the maximum)
1. Open Innovation is a high impact trend which will increasingly become widespread in the future	7,50
2. The potential advantages of Open Innovation outweigh the potential disadvantages	7.88
3. Open Innovation is a trend which carries minimal risks	4,38
4. Implementing Open Innovation initiatives tend to be simple; easy and straight-forward	3,38
5. Companies engaging in Open Innovation are more likely to be successful than companies that don't	7,13
6. Open Innovation is more useful as means of importing knowledge than exporting knowledge	5,00
7. Open Innovation is more useful as means of knowledge sharing than in creating alternative paths to markets	5.13
8. Open Innovation initiatives should be conducted in a centralized manner	3,63
9. Firms should aim to adapt their strategy/behavior/business model in order to increase the benefits of Open Innovation	6,38
10. Companies with rigid corporate structures are unlikely to successfully implement Open Innovation initiatives	5.88
11. Improving existing corporate partnerships is more beneficial than creating new partnerships	4,25
12. Corporate collaborations between firms in radically different markets are unlikely to be efficient and should be avoided	3,63
13. External collaborations under no IP restrictions tend to be more beneficial than with IP restrictions	5,63